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COMMAND AND CONTROL WITHIN THE
FRAMEWORK OF A THEORY OF COMBAT

by

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Combat command is an art. It derives its meager intellectual roots from empirical science. There is great current interest in grounding the subject of "command and control" (C2) from a sounder, more comprehensive point of view. This paper is intended to provide a general, internally consistent structure within which most C2 may be framed and analyzed. It departs from the usual approach by insisting that tactical C2 can only be described and analyzed in the context of combat itself. This research draws from a theory of combat and imbeds the C2 functions, processes, and supporting systems within the theory.

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Abstract: Combat command is an art. It derives its meager intellectual roots from empirical science. There is great current interest in grounding the subject of "command and control" (C2) from a sounder, more comprehensive point of view. This paper is intended to provide a general, internally consistent structure within which most C2 may be framed and analyzed. It departs from the usual approach by insisting that tactical C2 can only be described and analyzed in the context of combat itself. This research draws from a theory of combat and imbeds the C2 functions, processes, and supporting systems within the theory.

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Two command and control workshops sponsored jointly by the Naval Postgraduate School and the Military Operations Research Society are the second source of insight. Joel S. Lawson deserves separate distinction for his broadening perspective.

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A much more extensive set of acknowledgements could be prepared, but it hardly seems fitting to record them until there is an indication that this is not just another man's inadequate attempt to explain what we call command for combat.

COMMAND AND CONTROL WITHIN THE FRAMEWORK OF A THEORY OF COMBAT

Aim and Scope

Development of a theory of command and control (and leadership in the minds of some) is quite recent and still in flux. One constraint on progress is the absence of a general theory of combat, the matrix of command and control. Such a theory, under development by The Military Conflict Institute, is far enough along to draw from. Using that theory as the foundation it is the purpose of this paper to fuse current work in command and control into what is thought to be a self-consistent structure that is robust enough to treat the subject universally and coherently.

A theory of combat is a structure for understanding the phenomena of human beings in deadly competition. It is indirectly interested in "how to win battles", but its aim is descriptive, not prescriptive. This work is limited to command and control (C2) for combat: it treats the domain of tactics, which are the handling of forces in battle. It is probably inadequate for other military operations and their logistics, and is emphatically deficient in places regarding the role of C2 in strategy and military policy. Nonetheless the scope is greater than the activities of command during a battle (which might be called combat direction), because the command function establishes its influence much earlier.

Leadership is placed in context under the viewpoint that leadership is a human quality of someone in command. It will be seen that motivation is included as a function of command. Thus (1) a soldier ordered to charge the enemy must charge him or else the C2 function has failed, and (2) good and bad leadership has much to do with command effectiveness.

Often the emphasis in the study of C2 is on either the hardware, the organization of humans and hardware into a system, or the processes of C2 in the time domain independent of tactical context or specific purpose of the commander. This work does not neglect these more commonly treated aspects, but it is especially interested in relating C2 to combat. For instance, we will sever the combat process of information gathering and give it status separate from C2, while at the same time insisting that one of the major responsibilities of C2 is to direct the reconnaissance and surveillance effort, along with all other battlefield activities of forces commanded.

The author is intereated in the command and control problem both as a combat modeler and as a tactician (emeritus). No explicit analytical model appears in this paper, but the author has tested the concepts with equations that are internally consistent and escape the straitjacket of attrition models with which we now conduct combat analysis. In fact the equations came first in the evolution. As a tactician the author will never have a chance to put this work to use, a prospect he views with mixed feelings.

The Theory Structure: (1) Combat Potential and Power

The theoretical framework for this work is grounded in the fundamental proposition that combat is lethal force-on-force activity (force to be defined below).

We begin by postulating the existence of:

Forces: tangible entities which when activated by a commander against an enemy will produce combat power.

Designed combat potential: the designated or notional capacity of a set of forces to achieve useful results in combat when optimally organized, trained, equipped, supported, motivated, and led according to the design of the forces.

Available combat potential: the actual capacity of the forces to achieve useful results in combat with its existing organization, training, equipage, support, motivation, and leadership. Measurement of combat potential presupposes a characteristic or notional enemy and combat environment. AAW batteries are intended to be effective against aircraft, not infantry.

Combat power: the realized capability of the forces at any instant of time to achieve results in combat in furtherence of a mission against specific enemy forces in a specific environment.

Potential is a quantity drawn on to create combat power. Combat power *is a rate of effectiveness, but it does not* follow that potential is consumed in the generation of combat power the way electricity from a battery is consumed. Combat power is generated against an enemy by forces conducting activities ordered by a commander by means of a C2 process. It is general practice to associate a purpose, or mission, with the commander and with command and control.

We will now proceed to develop the above terms and the dynamics associated with them.

Theory Structure: (2) Forces and their Functions

Forces are tangible things, or elements, used for fighting: people and equipment. Every element has attributes which collectively are referred to as its state. Forces are assembled to perform one or more combat functions, which in the dynamic sense are performed as activities. The generic functions and the related activities of forces in combat are:

- o Commanding
- o Controlling
- o Information gathering
- o Moving
- o Supplying

- o Firepower delivering
- o Interfering with any of the enemy functions

These functions/activities can be described in detail, including quantitative detail, but functions by themselves should not be thought of as producing combat results, because they are defined independently of a specific recipient: enemy target or friendly beneficiary.

Theory Structure: (3) Combat Processes

When activated in combat, an element of forces performs specific actions (consistent with its functional attributes) which are intended to cause changes in the states of itself and other friendly and enemy elements of forces. The element-action-element triad is an activity which has a result that can, at least in principle, be measured. A shooter fires a burst from his weapon, depleting his magazine and achieving hits on his target.

Collective activities by functioning forces are called combat processes. The complex activity of firepower delivery (shooting, roughly) creates the processes of attrition and suppression on the enemy. Each process by one side has a countermeasure available to the enemy side. Each process has an observable effect which in principle is measurable. The combat processes are:

Process	Countermeasure
o Attrition (destruction or damage)	o Protection
o Suppression	o Covering
o Scouting (information acquisition)	o Screening
o Supply (or support)	o Interdiction
o Maneuver (or motion)	o Fixing (including disruption)
o Command and control (including communication)	o Counter-C2 (including deception)

Theory Structure: (4) Force

Force is the result of one side's collective activities (combined as processes) and the other side's attenuating activities (combined as countermeasures). Firepower measured on a firing range as hits per gun per minute will be altered by the enemy's protective countermeasures. In combat both sides apply force, so that fighting is complex force-on-force activity.

We see that it is conceptually inadequate to measure (or envision) combat results, from combat power alone, because of the need to account for enemy counteractions and (a factor not yet introduced) other uncertainties. Activities (triads) in practice are nearly always treated both analytically and operationally as a collective interaction of elements, their

actions, and the resulting changes to the elements' states. The collective activities and their effects, are aggregated as processes with collective, measurable results. A line of shooters fire at an advancing line of the enemy, which goes to ground to reduce its casualties. The hits achieved on the shooters' targets are now small, and the primary result is not to attrit (though this may be the shooters' intention) but to slow or stop the enemy advance: pin down the enemy. The processes of attrition and suppression occur concurrently, often with the most notable result being suppression, which it should be emphasized, is a salient form of degradation of the enemy's force.

Theory Structure: (5) The General Equation of Combat Power

In the above example the combat power of the shooters is synonomous with their fire power, and the force exerted by their combat power stops the enemy advance. Let us introduce the fundamental equation of combat power:

$$\vec{P} = F\ (\ m,\ \vec{u}\ )$$

Combat power, P, is a function of the attributes and number of forces, m, which in our example are solely elements assigned to shoot, and value of their activity, u, which is characterized by the skill with which they fire (rate of fire and accuracy), the terrain they cover and the range at which they open fire. The command function, F, governs the form of the equation (which might be m x u) as well as its values (number of shooters, terrain selected, open-fire range, etc.). A more complicated combat power equation might have divided the forces into shooters and suppliers running ammuntion to the shooters so that the fire could be sustained indefinitely. Then the action of the support elements is to maintain the readiness attribute of the shooter elements in a state we might call "armed for combat".

Command explicitly determines the division of labor in its forces between supporting and shooting. Command, in choosing the ground, fields of fire, dispersion, and open fire range determines the value of the activities it controls. Command implicitly determines other aspects (states) imbedded in the elements of its forces such as shooting skills, survival skills and cohesiveness, through organization, training, and doctrine.

Combat power is determined by the way in which command draws from its own combat potential in a battle. The resultant force depends, however, on decisions on both sides. Combat is inherently force-on-force activity, in which the effects of two opposing combat powers are simultaneously imposed on each other. Thus the command function is always concerned with competitive choices. This is true even when one side cannot shoot back, as with a antisubmarine aircraft against a submarine without AAW armament. The submarine will try to evade in turn, detection, localization, and attack by the aircraft. The tactics on both sides are complex, but unique from the usual image of a force-on-

force exchange of fire. The submarine generates zero combat power against the aircraft, but seeks to survive by evasion. The outcome of successful submarine countermeasures is zero attrition, but the aircraft's force is not zero because it neutralizes (suppresses) the submarine during its stalking operations. The aim of forces which cannot attack is survival, but survival against a Force takes activity under astute command.

Included Functions of Command and Control

The reason command and control have been difficult to deal with is that they are so multifaceted. The terms are concerned with:

- o Organization
- o Motivation
- o Decision
- o Execution

It is also possible to establish other categories of command influence, notably:

o education (which is associated not only with understanding but ideology, socialization, and cohesion)

o training (wich is associated not only with skills but with indoctrination and doctrine)

If the above four component functions of C2 are regarded as comprehensive, then all other categories must be treated as contained within them. Training would be a functional resonsibility of command accomplished under any or all of the four sub-functions.

The command function is hierarchical from "the national command authority" all the way down to the individual who commands and controls only his own activities. It is also circular: sound organization, motivation, decision, and execution reinforce both within and across the sub-functions, and weakness in one has debilitating feedback effects on the others. The dominant effects of command and control can be as abstract as the influence of an institutional ethos and as concrete as the difference between ordering and leading an assault.

We emphasize that command, control, and leadership all come in good and bad flavors. It is common, but dangerous, to refer to good results coming from command or leadership when one means sound command or good leadership. In general, theory of combat deals with the effects of battlefield attributes both good and bad (equipment, terrain, timing, surprise, and so forth). While achieving better command or leadership is a fundamental issue, that achievement is, in the context of the theory, principally a desirable end product. Theory must settle other matters first. Some historians devote their effort to the study decisive

battles, and the qualities of good and bad leaders at the extremes of the spectrum. As McQuie [1988; p. 5] recently pointed out, the *average* ground battle *from* 260 cases consisted of:

A division attacking a division
in a frontal attack against a fortified defense
with 17,700 men attacking 8,500
on an 8-kilometer front
in mild, dry weather
on rolling terrain
with mixed cover
without surprise
with the attack producing a penetration
and the defense resulting in a withdrawal.

In many of those "normal" battles (fought according to the norm) the qualities of leadership were splendid-- on both sides. Theory must give the norm its due. Historians are also wont to judge leadership as good or bad depending on good or bad battle outcomes. Theory must discern cases in which the leadership was sound, even exemplary, when the battle was lost. Contrariwise, one must never leap to the conclusion that because the battle was won the leader was talented. Theory is concerned, first and foremost, with establishing what constitutes the C2 function, and with advancing a framework within which the value of C2 can be adjudged. Indeed, the development of good leaders is a massive subject in itself, which can profit from theory of combat and the aspects that deal with command, control, and leadership.

Although C2 affects all elements under its command and their actions, C2 is not the actions of those elements except insofar as the elements belong to the C2 System (defined below) and the actions are part of the C2 Process. The C2 process decides what is needed from forces and transforms the need into action. The C2 process should not be thought of as the combat actions themselves. C2 governs "everything" in combat and its study can involve any or every aspect of combat, but C2 itself is not everything; "combat" is the expression for everything covered in theory or practice.

In particular it is common practice to view information gathering (detection, classification, tracking, targeting, and damage assessment) as part of the C2 function. This theory distinguishes information collection from C2. It treats information interpretation ("fusion") as part of the decision (i. e., C2) process. But collection through scouting, spying, cryptanalysis or any other means, is a distinct process with a measurable result which C2 governs. Indeed, selecting and distributing elements of forces for scouting is one of the major, distinctive responsibilities of modern command.

To say that C2 governs everything, as we have above, is not quite correct. It is possible to envision activity that occurs on the battlefield that has nothing to do with C2 or leadership. The

test cannot be whether the activity was ordered by a properly constituted command. Too many activities are "spontaneous", the deeply ingrained activities of individuals that are traceable to doctrine, self-command, or group cohesion. The test must be whether the activity is associated with mission accomplishment; whether it contributes to the collective aim of the forces in the battle. "Freezing up", getting lost, panic and a rush to the rear are activities which, if they are connected with C2 at all, are connected by a deficiency in it

Structure and Terminology

The military activity called command and control (C2) is both a function and a process. The C2 function organizes, motivates, decides, and directs the activities of forces. In the remainder of the paper we will call the all encompassing function simply command.

The C2 process alters the states (attributes) of forces. Usually the alteration is to forces which are commanded. In the remainder of the paper we will refer to the C2 process as command and control or simply C2.

Leadership activity is pervasive in command and control activity and, though not identical, must be treated as inseparable. Leadership is associated with that special set of elements, the commanders. Leadership is a quality of a commander which causes compliance with his desires (i. e., obedience plus the desired degree of initiative). The result of strong leadership is merely behavior in conformance with what the leader wants. Thus, strong leadership helps cause results, but strong leadership must be accompanied by sound decisions to produce good results. It is a combination of strength and soundness that we call good leadership. When a man not in the formal chain of command asserts leadership in the sense herein (altering the attributes of forces) then he is exercising off-line command and control. The term leadership also connotes qualities in an individual that create (or destroy) morale and cohesiveness. It is quickly seen that leadership affects not merely motivation, but organization, decision, execution, and notably in this instance, training as well. But neither the development of good leadership nor its characteristics are the subject of this work.

Combat Direction is a utilitarian term with fairly consistent usage. In this document it will refer to the command and control process on the field of battle. Thus it excludes (or downplays) organizational and motivational aspects, and emphasizes the decision process and sometimes execution.

Command and control as a process has come to indicate an organic unity and the interconnection will be retained in this chapter. If a distinction must be made, for my purposes "Command decides what is needed from forces and control transforms the need into action" [Hughes, 1986, p. 147]. Command is closely associated

with acts of decision; control is closely associated with execution of decisions made. In the etymology of "command and control", an early usage (associated with safeguards against the unauthorized release of nuclear weapons) denoted command as the power to act and control as a contraint on action. JCS Pub 1 currently defines control as "authority which may be less than full command over part of the activities of subordinate or other organizations", which is an exceedingly non-descript approach. Whatever their virtues these views of control seem to have fallen from common usage. We will reserve the term command and control to stand for a process, and the word command by itself to stand for the all encompassing function discussed above. Control will, because of diverse usage, blow in the wind, sometimes standing for the function, sometimes the dynamic process of carrying out a decision, and sometimes representing an aim to control the mind or will of a friend or enemy.

Command, Control and Communications (C3) and other expansions such as C3I (I = Intelligence) have been used almost synonomously with C2 as defined herein. Another usage coming to prominence (see for example Sweet, Metersky, and Sovereign (rev. June 1986)) denotes C3 as the communications process or activity associated with command and control. This usage is encouraged. The term C3 will rarely be necessary herein, because C2 connotes control including the means of control, namely communication of decisions.

A Command and Control System consists of a collection of denotable things that are used to perform the C2 function: physical elements (equipment such as transmitters and receivers, computers, a signal book, status boards and other decision support hardware, code breaking facilities, signal flags, etc.), human elements (communicators, staffs, intelligence analysts, the commander himself, etc.), and procedural elements (table of organization and command relationships, the content of a signal book, the content of a manual of training or doctrine, etc.). This collection of things is presumed in most usage to be integrated (actually form a system) in some sense. The purpose of the C2 system is to facilitate the C2 process. In some usage the commander himself is excluded from the system, which is then said to support him, but we will always conceive the commander to be a component of every C2 system. In a squad the commander and his voice may be the entire system. However primitive, there is always a C2 system, even when an isolated soldier directs himself.

A C3 System is not a term needed in this paper, but it can be defined, consistent with the term C3, as the communications elements and procedures that perform the C3 function.

[Some authorities would identify three systems, namely physical entities, structure, and the C2 process itself. This is cumbersome because physical entities and structure are so closely interwoven and because "system" is a term that has become

overworked. Moreover to work within this theory it is necessary for consistency to associate the C2 system with elements and C2 activities with results that alter the states of the elements.]

C2 Countermeasures (C2CM) are activities intended to lessen the effectiveness of the enemy's C2. C2CM may destroy his C2 elements or change their states ("confuse the picture"). C2CM may also interfere with his activities (jam his communications). These activities are well categorized in many sources, except to note that sometimes actions taken against his information collection are called C2CM and we regard this as improper.

A C2 Countermeasures System is a set of elements, like a communications jammer and its operator, that perform C2 countermeasures.

C3 Countermeasures (again a term not needed in this paper) are activities to lessen the effectiveness of the enemy's communications, such as the aforementioned jamming.

An alternative structure is advanced by Snyder (1988 draft) which has the merit of being tied to the agreed U. S. definition of command and control found in the Department of Defense Dictionary of Military and Associated Terms (JCS Pub 1). This reads: "The exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures which are employed by a commander in planning, directing, coordinating and controlling forces and operations in the accomplishment of the mission."

Snyder goes on to say "The first part-- 'The exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of the mission'-- will serve as our definition of the command function. The middle part of the DOD definition-- "an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander'-- will be used as our definition of a C3 system. C2 for our purposes will be defined (using the final words of the DOD definition) as the process 'employed by a commander in planning, directing, coordinating, and controlling forces and operation in the accomplishment of the mission.'

"[Thus] the term 'command' will be used to mean the function to be performed, the term 'C3' will stand for the supporting system, while the term 'command and control' will denote the process that commanders employ ('in planning, directing, coordinating, and controlling'), as they exercise authority and direction over assigned forces."

We cannot accept the JCS/Snyder terminology because many C2 functions the influence of which is too prominent to disregard are performed well before a combat mission is known. The

difficulty probably lies in a JCS emphasis on strategic "roles and missions". But this is a theory of combat. Activity away from the scene of battle, even in peacetime, to prepare forces to achieve their designed potential (we would say enhance their attributes) by training, organization, establishment of doctrine, and motivation may be the most important functions of command. The JCS definition above omits any mention at all of command responsibility to motivate forces. The JCS definition is very similar to the term Combat Direction as we accept it.

In other respects there is great similarity. We denote "the exercise of authority and direction [of forces]" as the command function.

We denote "the arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander" as the C2 system.

And we denote "functions performed. . .and [processes] employed by a commander" as Command and Control itself, or the C2 process.

The Functions: A Discussion of "Command"

The command function takes cognizance over all aspects of each element of its forces. It governs ("exercises authority over") them and prepares them for combat. In addition and most important in the terminology of this theory of combat, it activates them to create combat power for the composite actions we call battle. Insofar as this theory of C2 is concerned, the function of command for war in general is not specifically addressed but is presumed to be to direct forces to achieve wartime goals. In this paper the C2 function is specifically to distribute Force (as defined above) in time and space to accomplish combat missions.

The JCS definition of C2 speaks of four sub-functions: planning, directing, coordinating, and controlling forces. By defining management to be inherent in command, the JCS in effect add two more sub-function, organizing and evaluating, to its list. We prefer the four command functions, organizing, motivating, deciding, and executing, and regard them as necessary and sufficient.

By organizing its forces, command arranges the elements, establishes lines of command and communications, and codifies sound practice for united action, typically by formulating tactical doctrine or fighting instructions. A subsequent course of instruction in the Naval Postgraduate School curriculum for C3 students addresses organization in detail. Extensive literature in Management Science treats theory of organization exhaustively, but because its interest is in commerce and industry, the literature must be adapted for military purposes. Organization for combat is an art which has been finely honed empirically, and the organizational wisdom of management science has probably taken as much from the military experience as it has given in return.

By motivating its forces, command prepares the elements to comply with orders, both explicit and implicit, and execute the activities it desires under extreme conditions of violence. It does this by encouragement, compulsion, enjoinder and drill. Other techniques employed in the art and science of leadership are indoctrination and inspiration. Motivation is closely associated with cohesion, achieved by such measures as the inculcation of doctrine.

The effect of good organization and motivation is to raise the available combat potential of forces toward their designed potential. In other words, the principal effect is to alter the attributes (states) of the elements of forces and their interrelationships (structure). By definition, designed combat potential means the maximum capacity of a force that can be activated by a commander against a notional enemy. Available potential will always be less. Available potential is always a multiplier of designed potential that lies between 0 and 1. In

the structure of this theory of combat there can never be a "C3 bonus" that elevates available potential above the designed potential. Nevertheless the organizational and motivational effect of command can be massive. A disorganized, badly motivated battalion will have a multiplier close to zero, say 0.1. A well led battalion will have a multiplier close to one, say 0.8. Under those extreme circumstances, equal forces expressed as an order of battle will have an eight-fold difference in actual potential that can be activated. Almost no skill of command decision and execution on the field of battle can redeem the deficiency of the unprepared battalion.

Many theories of C2 disregard organization and motivation and leave them to organization theory and leadership studies. All, however, treat the next two subfunctions, namely decision and execution. Most associate themselves with understanding and improving combat direction-- sound decisions and more proficient execution.

By deciding, command determines what activities its forces should carry out. This function will be discussed further below, under The Purpose of the C2 Process with regard to the aim of sound combat decision making.

By executing, command achieves compliance among its forces with the decisions it has made. Execution is concerned with accurate communication of decisions and feedback to monitor compliance. Rightly or wrongly, the greatest attention in current U. S. C2 theory is devoted to the study of effective execution under the presumption that the decisions made were desirable.

Decision and execution are closely related because of the competitive aspect of combat, that is, the fact that both sides want to decide and implement their decisions in a way that is disadvantageous to the enemy. The C2 process confronts the commander's dilemma: a valuable decision must be timely, but the information on which the decision is based takes time to get. The decision-execution function is often studied with the well known "Decision loop", discussed below under the C2 Process. The decision-execution process, or C2 process, is closely linked to timeliness.

Commands are organized in such a way as to be able to think and act with blocks of forces. Similarly analysis is conducted with blocks of forces. This is because except at a very low level neither the commander nor the analyst is able to monitor and understand the interactions of each element and the effect of the actions on every other element. The question arises, what is the lowest level of granularity that the commander, or analyst, should concern himself with? An empirical rule of thumb is that he looks two echelons down. On what basis? The general answer is this: the blocks of forces (team, squad, platoon, company, battalion, brigade, etc.) should be the smallest grouping that

command needs to be informed about and control in order to accomplish its mission. Thus, a brigade commander in the heat of battle cannot be concerned with success or failure of a squad, except insofar as that squad is critical to the brigade's mission success.

This is, of course, only a general answer. The whole art of successful command and successful analysis is closely related to knowing which details are important and when. The ability to focus on important information is referred to as "a directed telescope" in Van Creveld [1985; pp. 75, 115, 142, 176, 255-257].

The Process: A Discussion of "Command and Control"

Command and Control is the process of activating organized and trained forces (thus transforming combat potential into combat power), and synchronizing their activities. C2 decides and causes decisions to be implemented. Communication is one principal means of control. Two other means not to be overlooked are doctrine and training. C2 causes (sometimes indirectly by organization and motivation) all other processes to occur. In fact it activates itself, and synchronizes its own C2 activities.

C2 is a cognitive process, in the sense that its results alter the state of knowledge, attitude or intentions of human elements. Recalling that the theory *of combat defines* elements and their actions and that elements have attributes, the result of the C2 process is a change of state of the attributes of human elements. The desired response to C2 by the human elements whose cognitive state is altered is to carry out commands or orders, causing a physical change of positions, a search plan, a field of fire, and so forth.

Here is a simple example. A soldier at position (x0, y0) is ordered to new position (x1, y1). His mind now holds the new information that the desired state for him is not his present state and he must decide how to act to go to the new position (walk or crawl, use stealth or move swiftly), and indeed under especially hazardous circumstances whether to move at all. Which method he employs depends on another attribute, which is the soldier's motivation to go to the new position, and which at the time of the order the superior cannot change, and so has a constant value z. The soldier's state z is really a complex vector of mental attributes the sum of which determine if and how he will move to position (x1, y1). Under most circumstances, for most combat simulations, and indeed for most commanders ordering a maneuver, both the soldier's compliance and some normal rate of movement to the new position are taken for granted. But the laws of human behavior are not like Newton's laws of motion for inanimate objects. The phenomenon (information and instructions to alter a cognitive state) required to cause a human being to climb a hill is different from the phenomenon (the potential energy of gravity) required to roll a truck down a hill. If the

world of physical science is composed of matter and energy, and the world of living organisms is composed of matter, energy and information, then the world of man is composed of matter, energy, information, and instructions.

The C2 System (discussed above and below) are physical elements, both human and material, that facilitate transfer of knowledge and change the cognitive states of other elements.

Symbolically the role played by C2 in the general combat power equation is as the functional operator, F, that maps forces, m, and their activities, u, into the space of possible states of combat power, P, available.

$$\vec{P} = F [m, \vec{u}]$$

Thus, this theory postulates that C2 is the governing process which transforms combat potential into combat power. The theory of combat further postulates that there is a two sided cause-and-effect relationship which transforms the C2-activated combat power of each of two foes into a Force pitted against another Force, which determines the outcome of the combat. [Incidental to the theory is an important implication that the outcome is related to the difference, not the ratio, of the opposing combat powers, but the development of this implication is beyond the scope of this paper]. Finally, it is basic to the theory that combat power only exists against an enemy in action.

The C2 process is often studied with a decision cycle. One form by Lawson and Moose is exhibited in Figure 1. For a summary of other similar approaches, see Foster [1988; p. 211].

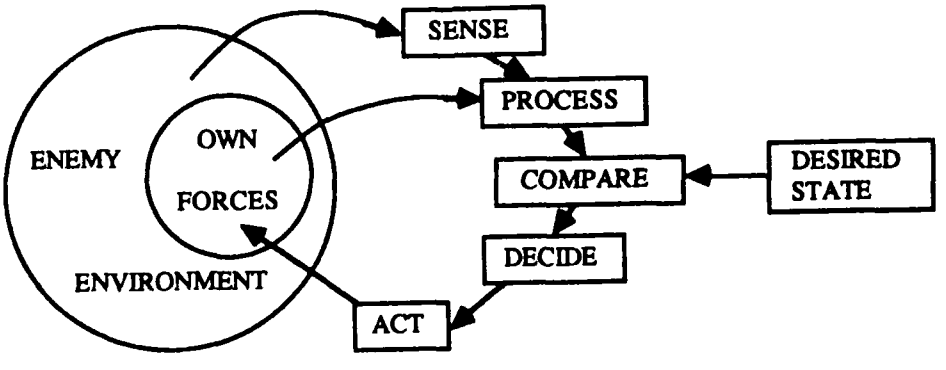

FIGURE 1

In this cycle the commander observes the state of the environment and then attempts to alter it by bringing it in conformance with a plan which specifies a desired end state, or a series of intermediate, time dependent states. The cycle is completely general and works at any level. The example above of a single soldier conforms with the cycle: he compares a new desired state (position x1, y1) with his existing state and makes a decision, directing his own actions. The decision cycle is studied in the time domain, and a common measure of effectiveness is the time taken to change the environment to conform with the plan. Great thought has been given in C2 analysis to ways to shorten the cycle.

Observe that elements of both the enemy's and one's own forces are part of the "environment". Orders executed by one's own forces are in fact the principal way of changing the environment. Also, sometimes it is possible to influence enemy forces by what Soviet theory calls reflexive control, or C2CM as the term is used in this theory.

C2 gives orders to sensing elements (radar, EW listening posts, search aircraft, reconnaissance parties, picket lines, etc.) to improve knowledge of the environment. C2 also gives orders to itself, to move, take cover, inspect the front, etc. The decision cycle has the power to look outside of the C2 process itself at the linkage between C2 and all the other combat processes. It makes possible the study of C2's effect on the activities of firepower delivered, or on the rate or quality (tactical significance) of reconnaissance and surveillance information, or on the proficiency of logistics support. With the decision cycle it is possible to examine the tactical context and "productivity" of a command decision, observing in detail the steps involved in the delivery of firepower, in search, in C2, or in countermeasures against the enemy. [See Hughes; 1986, pp 186-187].

On the rare occasion when the decision cycle can be analyzed without particular concern with what the enemy is doing, the theory of cybernetics can be drawn upon and the cycle visualized as a feedback loop. It is dangerous to draw from engineering control theory, however, because combat is a two sided process, in which the enemy is simultaneously trying to influence the environment at cross purposes with the friendly commander. The situation may be likened to trying to use a automatic feedwater regulator to sense the level in a boiler and keep the water at a certain height, but with a second operator present who wants to alter the level to suit his own perverse purpose.

The decision cycle is a major analytical tool used to study the execution phase of the C2 process. But observe that the decision cycle by itself presumes a command decision or set of decisions, including the initial operation order ("desired state"). Absent a separate mechanism for determining what decision should be made, the decision cycle is content free. A decision cycle does

not examine the "what and why" of command and control but merely the "how and when" of it.

Therefore let us look at the decision process. It has some long standing tools. The one with the longest pedigree is some form of the well known "estimate of the situation", which causes the commander and his staff to array his relevant choices against those of the enemy and to choose the one that fulfills the mission with the least risk. Game theory is similar, but quantifies the payoffs of the choice pairs and introduces the possibility of "mixed strategies." Both of these methods pay due attention to the enemy. One of their weaknesses is that the time dimension and the whole aspect of battle dynamics cannot be easily built into these tools of decision.

The estimate of the situation and game theory fall under the science called in general Decision Theory. For the military C2 theorist a grounding in decision theory has obvious advantages, but he must move quickly beyond it into the particulars of his own domain. Decision theory usually resorts to some mechanism for optimization which, when applied to battlefield problems, loses much of its power because of incomplete information, the difficulty of describing complex choices and responses with quanitative values (utilities), and other factors hard to capture in a formalism.

The wisest practice *seems* to be to maintain the bond between decision and execution represented by the term "command and control", so that the essence of sound decision and timely implementation cannot be separated.

Modern battlefield decision aids seem to keep the bond in place instinctively. It is fashionable (and wise) to express suspicion of tools of mathematics or logic at the same time that their use is (also wisely) mushrooming. We use automatic routing systems to move signals from sender to recipient. We use search and screening theory to deploy scouts and screens. We have imbedded target selection criteria in at least one of our most sophisticated AAW missile systems. The Soviet view favors decision aids not only to save time but also to exploit the wisdom of the best minds in a cooler atmosphere off the battlefield. All of the above examples include, indeed emphasize, the dynamics of the situation. It is hard to think of a utilitarian decision aid that is indifferent to time and timeliness. In the U. S. Navy the office of "aide" was orignially spelled "aid", up to and including the Secretary of the Navy's own principal adviser, the Aid for Operations. Whether one is describing the process carried out by a Decision Aid or a human staff assistant, the bond between decision and execution embodied in both kinds of aids seems to marry the two functions in a continuum of process.

A C2 System and Its Constituents

In this theory a C2 system is a set of elements intended to work together to carry out the the C2 process. They comprise physical elements, human elements, and procedural elements which together permit C2 activities to take place. Examples of these components are:

o Physical elements: radio transmitters and receivers, computers, signal lamps, laser signal equipment, signal flags, an underwater telephone, a communications satellite or communications relay ground station or aircraft, an airborne command post, a flagship, or the flag facilities in a warship, the tank in which an armored commander is riding, status boards and other decision support hardware, encrypting and decrypting hardware, a code book, or a one-time coding pad.

o Human elements: radio operators, staffs, intelligence analysts who interpret information for command, status board keepers, manipulators of decision aids, and the commander himself.

o Procedural elements: the contents of a table of organization, doctrinal publications, operation orders, a training manual, and instructions for the use of a decision aid.

A three-element system capable of performing the command function is a commander, an operation order, and a subordinate commander. When the commander hands the operation order to the subordinate and says "Learn this," the function of command is being performed, and the process of commanding can be measured by the degree to which the subordinate grasps what is in the oporder. The actions by the subordinate receiving the order to "learn this" and then studying it can be viewed as a single activity or two; the viewpoint depends on whether breaking the activity in to two pieces is relevant. In fact the commander will usually distribute to his several subordinates the operation order which contains directions to "execute this" and assume receipt, understanding, and action all of a piece. But no system can be studied or evaluated except with respect to some dynamic process.

A two element system with aggregated components of C2 might be A. a command headquarters comprised of commander and staff (organization and motivation implied) and physical elements (like radios) to receive and transmit information, and B. a soldier with a radio who is capable of shooting at something. Is the C2 process completed when A's order to B to shoot is delivered? If communications reliability is under study, then the act of B shooting is regarded as separate and not part of the C2 process. On the other hand command effectiveness may be the issue. Then the C2 process must be measured by the whether the soldier shoots (whether the C2 process triggers the desired action), and sometimes by whether the soldier hits a target. The usual study

of a C2 system focuses on transfer of data, so that delivery of an order is the terminus, but since command governs all, the full measure of command effectiveness is combat effectiveness. Nevertheless,the system we have been discussing is simply element A and element B.

The Purpose of Command and Control

If the C2 process is indeed a continuum of the decision and execution functions fused into a single dynamic like flying an airplane, then it is necessary to have a firm grasp of aim of the process. To study execution and its timeliness takes a general statement of purpose of command and control.

The first question for the science of C2 should be: What is the substantive (not procedural) aim or purpose of command? We have seen that C2 creates (activates) combat power. The operational aim of Command is to be able to distribute that power:

- o spatially
- o temporally
- o functionally

to achieve a goal, and when in combat to carry out a mission. By spatially is meant the positioning of blocks of forces at a certain place. By temporally is meant the positioning of forces in a certain time or sequence. By functionally is meant assigning forces to do certain things, very similar to the operational term, a tasking. The result of a wise C2 process is a proper distribution or allocation of combat power against the observed or anticipated distribution of the enemy's power.

Let us look at the hierarchy of combat goals. At its most succinct the purpose of combat is to achieve a mission. Implicit in the superior commander's assignment of a mission is an estimate of the combat power that the executing commander will generate and distribute in the face of a specific threat (mentally conceived by the tasking commander as opposing combat power) in a conjectured environment. A pertinent, and sometimes underplayed, influence on the level of combat power the executing commander will be able to generate is any constraints ("rules of engagement") imposed by the tasking commander. Also implicit is a value of the mission objective in the superior commander's mind.

Second in the hierarchy of combat goals is this. Only rarely is the mission to be accomplished "at all costs". If it is, the mission statement will likely say so; if it is not, then "at reasonable costs" is implicit. Does the executing commander have any guide to what cost is reasonable? In practice the personality of the tasking commander is probably the best guide. In principle, or in the judgment of posterity, a suitable guide

is a comparison of the net change in combat potentiality of the two sides at the end of the battle.

Let us say the combat potential of forces of an attacker we will call A is 100 units, and that an estimate of A's realizable combat power is 100 units per day. A's mission is to cross a river and establish a bridgehead. The potential of the defender, D, is 25 units, but when postured behind the river, D's combat power is 75 units per day. The superior commander orders A to attack because in his mind's eye after A has achieved the opposed crossing, D will retreat and only be able to generate combat power of at most 25 units per day. He envisions a loss of A's potential of 10 to 15% during the assault, so that mission accomplishment will net him a final potential of 85 to 90 units against less than 25 for the enemy, who will have lost the important strength of his position behind the river.

The bridge is assaulted and taken. Because of a stubborn defense, A suffers severe losses, and his combat potential for pursuit of D is reduced to 60 units. D's losses were light and his potential is still 25 units, but as expected, his available combat power is now only 25 units per day. Faced by 60 units of A, he must retreat until he can establish a new defensive position that promotes his potential sufficiently to defend against A. The tasking commander may be satisfied, despite A's losses, for another reason. If A goes over to the defense, his fighting strength is enhanced by his new position, and is worth, say, 180 units per day of combat power against an enemy assault.

In such a way as this can the reasonableness of losses be put in mission perspective. An old question that haunts commanders, military historians, and analysts alike has to do with the peripherals: put aside the present postures for a moment and take the longer view. A's potential was reduced from 100 to 60 units. D's potential remained constant at 25. From a strategist's point of view, did his tactical commander achieve a Pyrrhic victory? Take another viewpoint. With fewer losses could the river have been crossed upstream or down by deception and surprise? The question of where to draw a line around the causes and effects of combat has been called the teleological problem [Thomas, 1984, pp. 303-306]. Such issues are far more important than whether the precise assessment of combat potential of A should have been 90, 100, or 110 units. The right strategy and the right tactics are more important than exactly the right numbers.

Therefore we will do well to consider, third in the hierarchy of combat goals, mission accomplishment in terms of means and ends. As in most combat theory, <u>domination</u> is the fundamental means.*

*Control and influence are alternative terms used. The stronger term <u>domination</u> seems most fitting with regard to tactics and the battlefield, and the weaker terms control or influence more fitting for strategy and policy.

The object of combat is to dominate the enemy (to some end called the mission) and a commander searches for combat processes which will dominate him. Attrition is one way, but so are suppression, surprise, and maneuver to a superior position. Giving domination the primacy it deserves helps in the search for ways to avoid the casualties of a frontal assault.

Fourth and last in the hierarchy of goals, we return now to the general decision of command: how to distribute combat power with domination in mind. When battle is imminent a commander seeks to activate his forces to achieve their greatest potential over the course of it. On the eve of battle he distributes his potential in blocks, the combat power of which threaten to dominate the enemy to greatest effect. The ultimate source of combat power is blocks of well-positioned and directed lethality, but even when the lethal substance is firepower it may be lethality in the offing, created by maneuver. In one paradigm, effective Force against the enemy is a combination of fire and movement. We wish to emphasize that effective Force must be measured in a richer way than the number of casualties inflicted. It is not necessary to abandon the belief that the threat of destruction lies behind all success on the battlefield to believe that actual destruction is not always necessary to achieve a mission. That is the warp and woof of Sun Tzu's wisdom in "Offensive Strategy", Chapter III of The Art of War [1963]. The enemy defender may be suppressed, outmaneuvered, surprised, dissplrited, and by some such cause be literally "forced" back, forced to surrender, or in another fashion be bent to the will of the attacker.

Thus is expressed the notion of dominating the enemy to achieve the mission by the effective application of Force represented in a quantity of combat power that is drawn from the commander's combat potential.

Here is an example of distributed combat power: "C2 planning must deal with tactical content (the desired state). Let us explore this important point. One style of ground attack is to direct operations along a front by specifying for each force element a geographical objective, its desired state. [See Figure 2]. Reinforcements are then sent to the places where operations are experiencing the greatest difficulty. Success is viewed as the simultaneous attainment of all objectives. In this case, victory depends on the absence of exposed flanks. A second, contrary style is to strengthen places along the front where operations are succeeding, reinforcing success with the object of snowballing it. [See Figure 3]. In this case, victory depends on a breakthrough followed by exploitation. In naval operations, the successful defense of a battle group depends on the timely augmentation of AAW, ASUW, or ASW forces when necessary to handle air, surface, or subsurface attacks. In strike operations one virtue of naval mobility is the threat of attack and the exploitation of enemy vulnerability whereever it is found." [Hughes; 1986, p. 188]

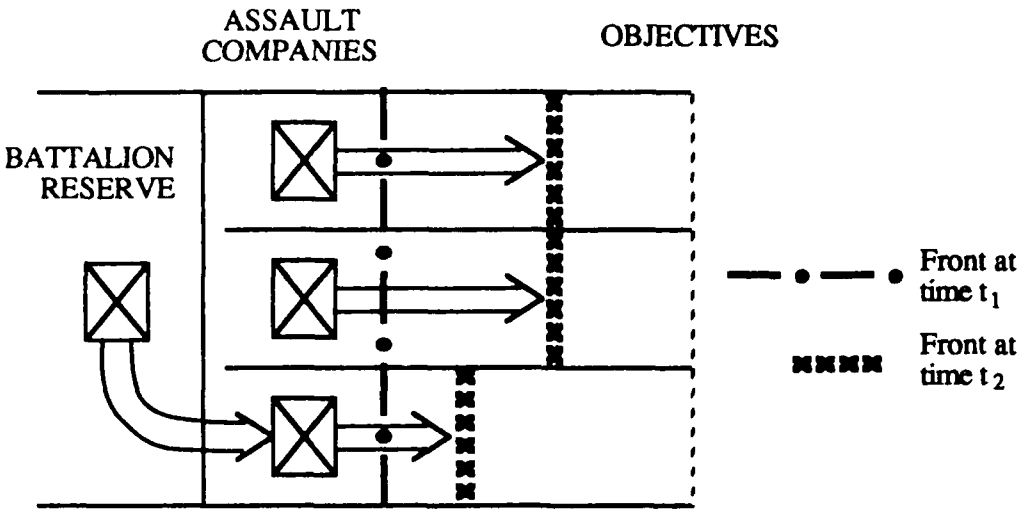

FIGURE 2
REINFORCEMENTS ARE SENT TO THE COMPANY ON THE RIGHT FLANK WHICH IS HAVING DIFFICULTY REACHING ITS OBJECTIVE

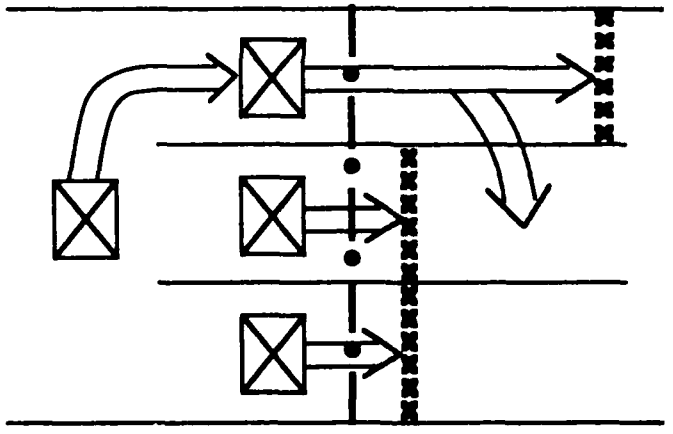

FIGURE 3
REINFORCEMENTS ARE SENT TO THE LEFT FLANK TO EXPLOIT THE OPPORTUNITY OF A BREAKTHROUGH

The Value of Command and Control

A question of immense practical importance is, what is the value of C2? In a word the issue is, how much inferiority in designed combat potential (i. e., numbers) can superior C2 hope to overcome? We have already seen that the answer is, sometimes a great deal.

Often the question posed is this: everything else being equal, will a new and powerful set of C2 hardware be worth the cost? The reason the question is difficult is because the payoff is properly measured in combat power, or a proxy, combat potential. Say it is certain that with the new hardware A's decision cycle can made faster than B's by 20% each and every time on the battlefield. What is that worth by some combat measure of effectiveness like casualty exchange rate? The new C2 system's time advantage of 20% could be worth 20% in combat effectiveness, or a paultry 2%, or a war breaking 200%.

The answer much depends on circumstances which are difficult to foresee when the peacetime purchase of the C2 hardware is contemplated. There seems to be no general answer, but research might yield some surprising insights. It is in the historical record that the more the commander is in control of all combat activities, the more difference the qualities of the commander and his equipment make in the outcomes. Ace fighter pilots rack up extraordinary strings of victories in a combat lifetime. Inexperienced fighter pilots have a very short life expectancy. Pilots of single seat aircraft have almost total command and control over their "forces": themselves and their machines. The spread of results is from more than 100 victories at the top of the scale to none at the bottom.

The record shows the spread between ace and goat submarine skippers in sinking shipping is also great, but not as great as for fighter pilots. Among German U-boat commanding officers in World War II, 10% of them inflicted 45% of the casualties to allied merchant ships. At the other extreme, 46% of them hit nothing. It is the nature of submarine combat that the commanding officer has very tight command of his ship and crew, though not as complete as for a pilot.

For ground operations, one historian studied the difference in the combat effectiveness between 24 Western European divisions in World War II. He concluded that the difference between the best and the worst was only in the ratio of two and one-half to one. [Dupuy: 1987, p. 116]. A commander of a division exercises C2 over thousands of men and pieces of equipment and, compared to the air and sea examples, it is inherently a highly distributed control as well.

The above comparisons are not rigorously compatible. However, a recent, well structured approach by Bolmarcich [1989] has fit the

pilots, submarine commanding officers, and tank commanders. Bolmarcich shows quite a tight fit of the Polya parameter (Beta), and concludes "To our mind, it [the narrow range of derived parameter values over all cases] points to some law of human group behavior with a stability rivaling that of the physical sciences." There are threads in the foregoing that ought to be pulled together, under some such hypothesis as a "Theory of the Expert". Still, one is left with the feeling that the potential of C2 in general, and C2 material in particular, to influence outcomes will be proportionate to how directly the commander is able to implement his wise or foolish decisions.

Measures of Command Effectiveness

The above discussion is a reminder that one cannot evaluate without measures of effectiveness. Command effectiveness is tied to combat effectiveness. It is not the function, command, that is to be measured, but the results of the process, command and control. Some excellent work has been done toward drawing together the entire command and control community -- producers, purchasers, commanders, staffs, and analysts-- to establish a common basis for evaluation of C2 systems [see for example, Sweet, et al.; 1986]. These efforts acknowledge the difference between (a) measures of genuine force effectiveness (MOFEs) which we have discussed above, (b) measures of C2 effectiveness (MOEs) which isolate the C2 system or process, and (c) technical measures of performance (MOPs) of C2 components. A major aim of the science of command and control ought to be to study the linkage between an MOE value (like the length of time to go around the decision cycle) and the more difficult to measure MOFE which is related to the payoff in a battle. How often is the MOE, time to act, a satisfactory proxy for the MOFE, combat outcome?

On the subject of effectiveness measures, John Dockery [1985] is at once profound and encouraging. Profound because he insists that MOEs require a mathematical definition that is able to combine quantitative valuations of disparate qualities-- which is the case both with command and with combat results-- and he is so bold as to advance fuzzy sets as the way to do that. Encouraging because he believes that when decisions are involved, "measures are always intended to communicate information which will allow a [mere] rank ordering of the conflicting goals and desires facing an organizational decision maker." Be that as it may, a reading of Dockery suggests that much can be done and needs doing. He also concludes that a measure can be defined (said to "exist") only within some problem context. We share the conclusion that specific problems require specific study, but in addition believe that a sound theoretical structure will lead to some general quantitative relationships between between better command and better battlefield outcomes.

There is an enormous literature devoted to every aspect of command and control. It includes studies of organization,

motivation, decision making, and execution. The literature covers the command function, the command and control process, and command and control systems. Most of the studies applicable to the science of combat C2, which is concerned with two-sided activity in an environment charged with physical violence, are empirical and prescriptive: they are concerned with what to do or how to do it. By and large the missing element is insight into "If I do it, what's it worth?" as well as "What will it cost-- in dollars, or lives, or time, or morale?" Deep as these questions are, the understanding of command and control will not advance far without keeping the questions at the forefront and struggling with the answers.

We began the previous section with the rhetorical question, how much numerical inferiority can superior C2 hope to overcome? Add to this two more questions:

o How often will the opportunities arise?

o To what extent can the separate values of C2, training, quality of combat equipment, and combat experience be isolated and measured as the explanation of a series of outcomes?

In their chapter, "The Use of Measures of Effectiveness", Morse and Kimball (1950; pp. 45-46) posed this question and could go no further then to encourage its study. These are the questions this paper is intended to help with, and to which it wants to direct attention.

Summary and Conclusions

1. The structure over which it is presumed that command exercises its influence is, in most general form;

- o forces
- o combat potential
- o combat power

2. A commander organizes and motivates his forces to create combat potential. He activates his combat potential against an enemy to create combat power.

3. By activation is meant to cause forces to carry out specified activities. As a result of activation, dynamic processes occur with observable effects, which when aggregated create combat power.

4. The effect of side A's combat power directed against an enemy, side B, and the enemy's measures to attenuate its effect when combined result in a measurable Force of A against B. Side B simultaneously applies its attenuated combat power against A. In combination, the consequence is a force-on-force process called combat, with a measurable result called an outcome.

5. Force is a real phenomenon, comprising physical, mental, and spiritual factors. Force always involves, in threat or reality, the delivery of lethal violence. The outcome of applying force is a complex change in the attribute states of the forces. Force is more than a tabulation of forces and outcome is more than battle casualties.

6. It is useful to distinguish:

- o C2 functions: responsibilities of command; that is, acts or operations expected of a commander.
- o C2 processes: the acts or operations that ensue when command exercises its authority and responsibility.
- o C2 system: a collection of things used to perform the C2 functions.

7. Although C2 affects all forces under its command and their activities, C2 is not the activities of those forces except when the elements of forces belong to the C2 system and the actions are part of the C2 process.

8. The general object of a commander is his mission. A commander achieves his mission by applying his combat power in such a way as to dominate his enemy. In operation, command distributes its power spacially, temporally, and functionally.

9. A primary problem of command is deciding how to distribute combat power simultaneous with deciding on measures to attenuate the enemy's combat power. Decisions are taken against thinking, acting opposition.

10. The problem of decision is closely associated with the problem of execution, because the decisions must be made in time for the forces to carry out their intended activities.

11. If the process of deciding is called command and the process of executing is called control, then the two are inextricably intertwined and studied as the C2 process.

12. Two other fundamental issues are:

o The value of C2 and its contribution to combat power, force, and outcomes.

o Measurement of the effectiveness of C2 and the suitability of proxies (called MOEs) as substitutes for measures of ultimate battle payoff (called MOFEs).

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APPENDIX A: DEFINITIONS RELATED TO COMMAND AND CONTROL

[Military] Forces: a set of elements which when activated by a commander will produce combat power.

Combat [process]: the activities of forces in opposition which produce results on a battlefield.

[Military] Potential: the latent capacity of forces to achieve useful results in combat.
Designed potential: the maximum capacity evisioned; rated capacity.
Actual potential: capacity available under the circumstances.

Combat Power: the realized capability of forces at any instant in time to achieve results in combat in furtherence of a mission.

Force: the observable effect of combat power on an enemy [in a battle].

Command: the function which organizes, motivates, makes decisions regarding, and directs the activities of forces.

Control [when used alone]: the function that executes command decisions.

Commander: one who commands forces.

Mission: the goal assigned to a commander toward which he directs the activities of his forces.

Leadership: the characteristics of a commander in the execution of command responsibilities.

Command and Control [process] (C2): the generic name for activities which themselves activate all elements of military forces for (i. e., preparatory to and during) combat.

Combat Direction: the activities of the C2 process that govern the activities of forces in combat.

Command, Control and Communications [process] (C3): activities of communication that are imbedded in C2.

Command and Control System (C2 system): the elements used to effect the C2 process.

C3 System: the elements used to communicate in the C2 process.

C2 Countermeasures (C2CM): activities intended to lessen the effectiveness of the enemy's C2 process.

C2CM System: the elements used to effect the C2CM process.

APPENDIX B: ADDITIONAL TOPICS FOR STUDY

The following topics are recommended for study within the framework established by this research.

1. Illustrations and tests of the C2 process by means of some basic analytical combat models, contrasting the usual attrition form of them with the form when combat power and force are developed. Map a program to test the models with exercises and historical data.

2. The framework should be examined for robustness and internal consistency in a variety of combat environments:

- o Static warfare, such as trench warfare
- o Siege
- o Mobile warfare, such as blitzkrieg
- o Naval fleet action
- o Aerial duels
- o A charge, such as by infantry, cavalry or tanks, with or without preparation and supporting fire.
- o Flank attack
- o Tank battle
- o Ambush
- o Urban warfare
- o Deep attack

The essential questions are: is the structure sufficient? and is everything in the structure necessary?

3. The effect of the scale of the war on both the tactical C2 process and the system. Specifically some distinguishing features of C2 in a crisis with limited or no application of force; in theater conventional warfare; and the tactics [sic] of combat in global nuclear warfare.

4. C2 architecture is a concept in vogue. Is there a synergistic relationship between the applied or "engineering" science of C2 architecture and the basic science represented by this research?

5. Combat power appears in this theory in an heuristically appealing way to most military men. Physical power is work per unit time, or in some mechanical systems, forward thrust

represented as force times velocity. It is difficult to see how the complex combat power defined as F [m, u] will reduce to physical power when mental and spiritual aspects are removed, but it can be shown that combat power can be reduced to momentum, and combat force is the first derivative. What is the best term for the phenomenon we have called combat power? Combat potential as military potential energy deserves wringing out as well.

6. The enumeration of basic trends, like the expansion of the battlefield and the influence of cryptanalysis, and their probable effect on tactical C2 in future wars can and should be examined within this framework.

7. Regarding control through organization, the tendency over the course of battle is thought to be toward a state of chaos. The concept has been advanced elsewhere of self-regenerating nodes of order on a battlefield to reduce entropy. Is this application of Prigogene's work a useful approach?

8. Development of the concept of Cohesion and Disjunction and the role of command to promote the former and lessen the latter. Cohesion and disjunction are so closely related to organization and motivation that these C2 functions are essential to any treeatment. The theory offers an approach by admitting the effect of a change of attributes on the performance of human elements.

9. A thoughtful discussion of combat Doctrine, its purposes and limitations. Should the ideological aspects be emphasized (internal effects on individual members of a unit), or the coordinational aspects (the effects on the unit as a whole in fostering cooperative effort)? Each has been stressed, but rarely both at once.

10. Investigation of areas ripe for development, like surprise and one of its primary sources, deception. Surprise is acknowledged as having a primary effect on battle outcomes, and much of C2 is concerned with achieving or preventing it. The first priority should be to develop a way to examine the value of surprise in terms of combat power or force.

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